Carbon exchange rates in *Polytrichum juniperinum* moss of burned black spruce forest in interior Alaska

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ABSTRACT

Boreal black spruce forest is highly susceptible to wildfire, and postfire changes in soil temperature and substrates have the potential to shift large areas of such ecosystem from a net sink to a net source of carbon. In this paper, we examine CO_2 exchange rates (e.g., NPP and Re) in juniper haircap moss (*Polytrichum juniperinum)* and microbial respiration in no-vegetation conditions using an automated chamber system at 5-year burned black spruce forest in interior Alaska during the fall season of 2009. Mean microbial respiration and NEP (net ecosystem productivity) of juniper haircap moss were 0.73 ± 0.36 and 0.75 ± 1.04 mgC/m^2/min, respectively. CO_2 exchange rates and microbial respiration showed temporal variations with fluctuation in air temperature during the fall season, suggesting the temperature sensitivity of juniper haircap moss and soil microbes after fire. During the 45-day fall period, mean NEP of *P. juniperinum* moss was 0.49 ± 0.28 MgC/ha after 5-year-old forest fire. On the other hand, simulated microbial respiration normalized to a 10 °C temperature might be stimulated by as much as 0.40 ± 0.23 MgC/ha. These findings demonstrate that fire-pioneer species juniper haircap moss is a net C sink in burned black spruce forest of interior Alaska.

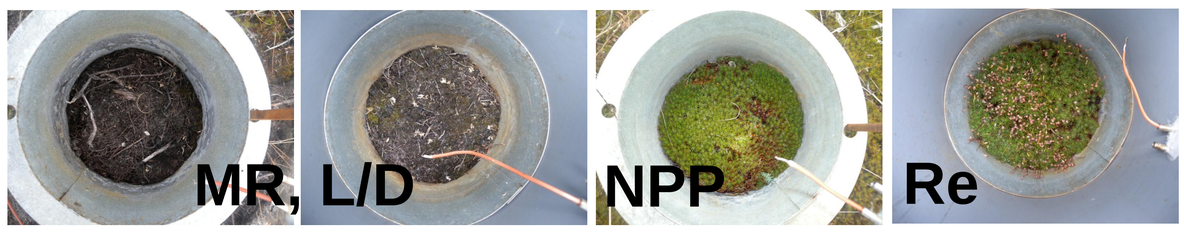
Materials and Methods

1. Research Site

* Poker Flat Research Range of UAF (65°08´N;147°26´W;491 m),
* Severely burned black spruce forest in June 2004,
* Dominant species: paper birch, quaking aspen (*Populus tremuloides*), Labrador tea, bog blueberry, sedge, fireweed, and juniper haircap moss (*Polytrichum juniperinum*),
* **Juniper haircap moss:** the first ground-layer species to establish after fire (Foster, 1985), *this study focuses on the carbon dynamics of juniper haircap moss during the fall season.*

2. Carbon dynamics in juniper haircap moss

- GPP, Re, NPP, and MR (microbial respiration),
- MR ∝ Soil Temperature, and
- Simulated MR normalized to a temperature of 10 °C.



Results and Discussion

3.1. Environmental factors

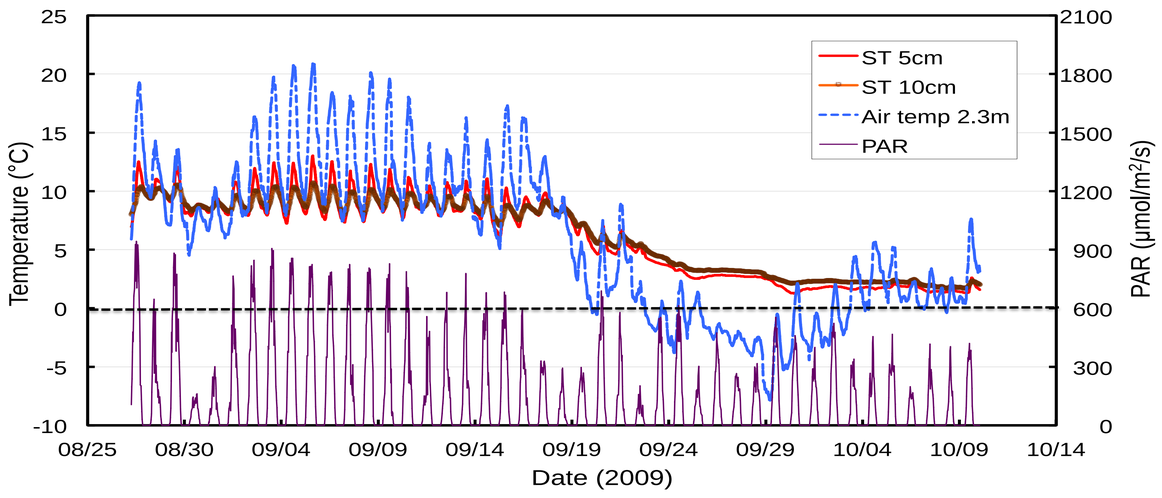


Fig. 1. Seasonal variations in soil temperatures at depths of 5 and 10 cm, air temperature at 2.3 m, and PAR in burned black spruce forest of interior Alaska during the fall season of 2009.

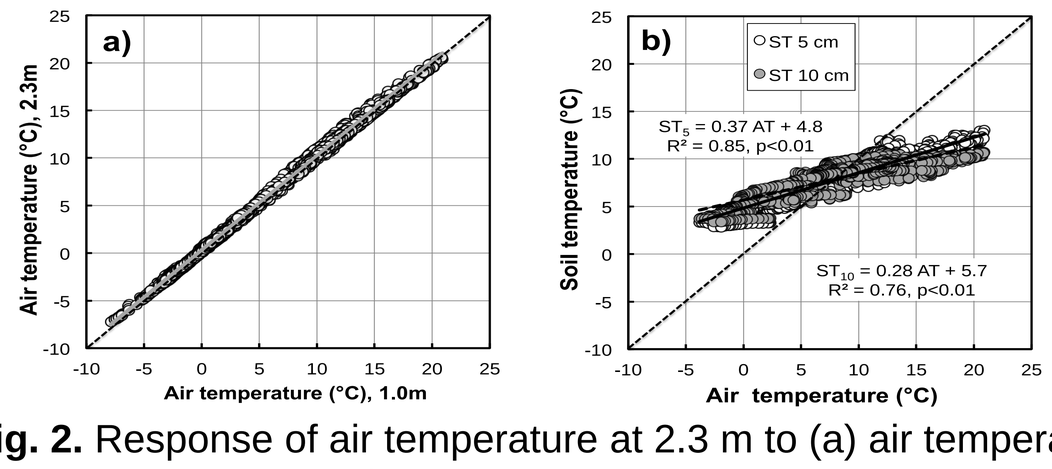


Fig. 2. Response of air temperature at 2.3 m to (a) air temperature at 1.0 m, and to (b) soil temperature at depths of 5 and 10.

3.2. CO_2 exchange rate in juniper haircap

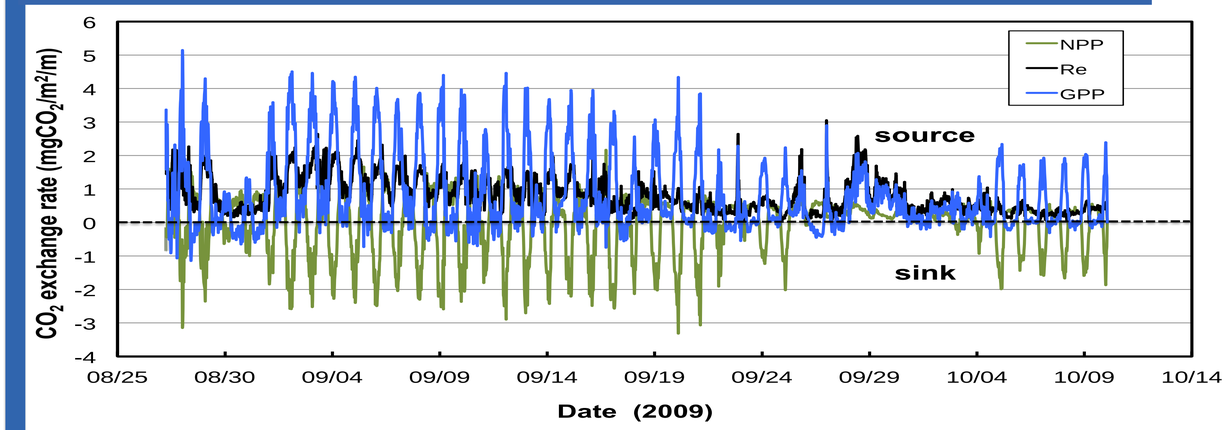


Fig. 3. Seasonal variations of NPP, Re, and GPP in common haircap moss of burned black spruce forest of interior Alaska during the fall season of 2009. Source, in which carbon dioxide emits to the atmosphere, appears over the zero as Re and GPP; and sink, in which the moss photosynthesizes, shows below zero, as NPP.

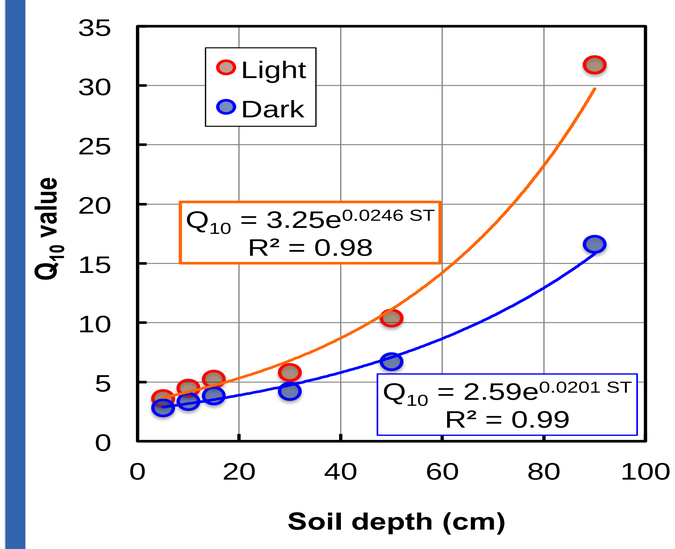


Fig. 4. Response of Q10 values to soil temperature at multi-depths using light and dark chambers in black spruce forest after fire.

3.3. Microbial respiration normalized

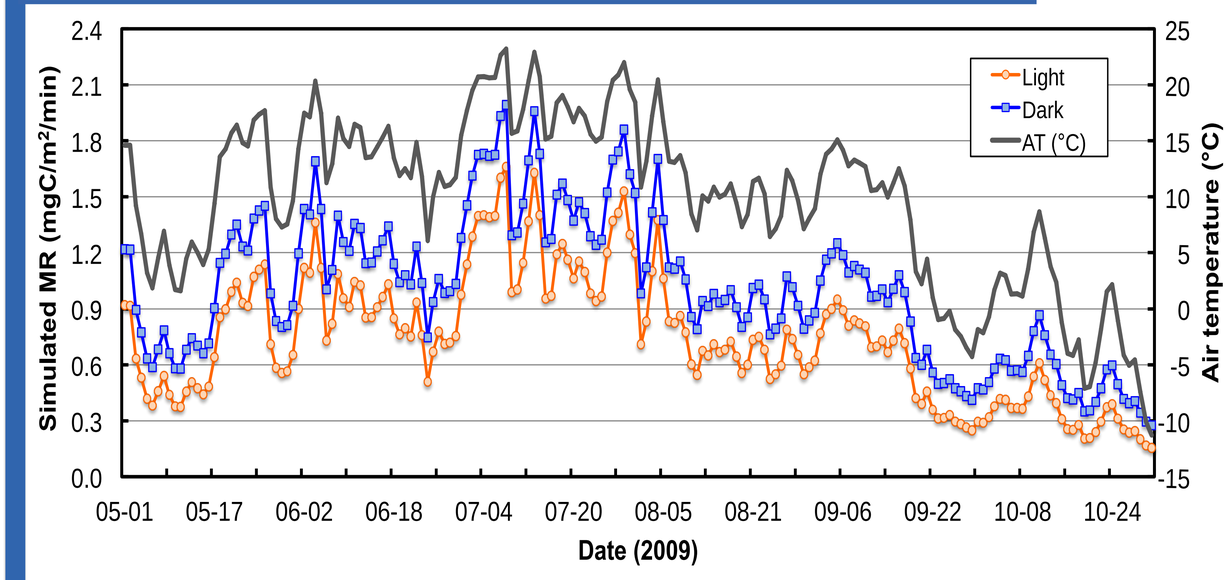


Fig. 5. Temporal variations of microbial respiration from light and dark chambers, and air temperature at 2.3 m during the growing season (May to October) of 2009, based on relationship between measured and simulated MR, and the estimation of the equation.

CONCLUSIONS

CO_2 exchange rates (e.g., NPP, Re, and GPP) were measured in juniper haircap moss, a fire-pioneer species, with light and dark chambers, and microbial respiration was measured in a no-vegetation regime of burned black spruce forest after forest fire, in interior Alaska during the fall season of 2009. Mean NPP, Re, GPP, and NEP were -0.02 ± 0.90, 0.82 ± 0.53, 0.84 ± 1.13, and 0.75 ± 1.04 mgC/m^2/min, respectively. Mean microbial respiration by light and dark chamber yielded 0.57 ± 0.26 and 0.80 ± 0.30 mgC/m^2/min, respectively. CO_2 exchange rates and microbial respiration showed temporal variations with fluctuation in air temperature during the fall season, suggesting temperature sensitivity of juniper haircap moss and soil microbes. Microbial respiration from light and dark chambers followed soil temperatures at various depths of 5-90 cm with increasing exponential curves, indicating that Q_{10} tends to increase with measured soil depths, and shows maximally 31.8 and 16.6 at a depth of 90 cm, from light and dark chambers, respectively. *During the fall period of 45 days, mean NEP of P. juniperinum moss was 0.49 ± 0.28 MgC/ha five years after forest fire, demonstrating that juniper haircap moss is a net C sink in the burned black spruce forest of interior Alaska.*

Simulated microbial respiration normalized to a 10 °C temperature is nearly similar to measured microbial respiration, showing a good correlation relationship between both. On the basis of this relationship and measured air temperature, simulated microbial respiration showed temporal variation during the growing season (May to October) of 2009. During the fall period of 2009, microbial respiration might be stimulated by as much as 0.40 ± 0.23 MgC/ha in the burned black spruce forest of interior Alaska, indicating findings similar to those measured in other burned black spruce forests during the fall season. *Hence, P. juniperinum moss, a fire-following species, represented a net C sink in this five-year burned black spruce forest of interior Alaska during the fall season of 2009.*

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